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# **EPA's SF<sub>6</sub> EMISSION REDUCTION PARTNERSHIP: MAXIMIZING THE BENEFITS OF SF<sub>6</sub> EMISSION REDUCTIONS FOR ELECTRIC UTILITIES**

Jerome Blackman<sup>1</sup> and Ravi Kantamaneni<sup>2</sup>

## **1. INTRODUCTION**

First manufactured in 1902, sulfur hexafluoride (SF<sub>6</sub>) is a fluorinated compound with an extremely stable molecular structure. This structure makes it far superior to oil or air in its insulation properties, dielectric strength, and arc quenching abilities. Electric equipment manufacturers and utilities therefore rely heavily on SF<sub>6</sub> in transmission systems. In 2001, electric utilities and electrical equipment manufacturers (OEMs), taken together, purchased over 80 percent of all SF<sub>6</sub> produced worldwide (1). Under ideal conditions, SF<sub>6</sub> would remain contained within transmission equipment. In reality, however, SF<sub>6</sub> is inadvertently emitted into the atmosphere as leaks develop during various stages of the equipment's lifecycle. SF<sub>6</sub> can also be accidentally released during equipment installation, servicing, or de-commissioning.

SF<sub>6</sub> has been identified by the Intergovernmental Panel on Climate Change (IPCC) as a highly potent greenhouse gas that contributes to climate change. According to the IPCC (2), SF<sub>6</sub> is 22,200 times more effective at trapping infrared radiation than an equivalent amount of carbon dioxide (CO<sub>2</sub>) over a 100-year period. Additionally, it has an atmospheric life of 3,200 years; its accumulation in the atmosphere is virtually irreversible. Measurements taken from 1978 through 1996 indicate SF<sub>6</sub> concentrations are increasing in the atmosphere at a rate of 7 percent per year (3). In 2002, SF<sub>6</sub> emissions from the U.S. electric power industry totaled 589 metric tons. From a greenhouse gas

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<sup>1</sup> U.S. Environmental Protection Agency, Climate Protection Partnerships Division, 1200 Pennsylvania Avenue, N.W., Washington, DC 20001, USA.

<sup>2</sup> ICF Consulting, 1725 Eye St., Suite 1000, Washington, DC 20006, USA.

perspective, that equates to 14.1 million metric tons of CO<sub>2</sub>, or 5 percent of total CO<sub>2</sub> and non-CO<sub>2</sub> greenhouse emissions from U.S. industrial processes (4). Although SF<sub>6</sub> is emitted in smaller quantities than other greenhouse gases, it has a significant long-term impact on global climate change. Consequently, the need to minimize SF<sub>6</sub> releases and avoid its accumulation in the atmosphere is important.

## **2. SF<sub>6</sub> EMISSIONS REDUCTION PARTNERSHIP FOR ELECTRIC POWER SYSTEMS – SF<sub>6</sub> Emission Reduction Activities**

The U.S. Environmental Protection Agency (EPA) launched the SF<sub>6</sub> Emission Reduction Partnership with the electric power industry in 1999. Currently, more than 70 companies – representing all segments of the U.S. electric utility industry, have voluntarily committed to identify, implement, and report the results of their emission reduction activities. The Partnership provides a forum for the industry and EPA to share information of ways to reduce SF<sub>6</sub> emissions to technically and economically feasible levels.

The efficiency of SF<sub>6</sub> management can be improved through cost-effective operational improvements and equipment upgrades. These opportunities fall into four categories: SF<sub>6</sub> inventory tracking systems, SF<sub>6</sub> recycling, improved leak detection technology, and SF<sub>6</sub> management training programs to improve operation and maintenance practices.

### **2.1 SF<sub>6</sub> Inventory Tracking Systems**

Each year, SF<sub>6</sub> Partners prepare and submit reports to EPA that detail their annual SF<sub>6</sub> emissions and emission reduction achievements. SF<sub>6</sub> emissions estimates are prepared using a mass-balance approach to systematically track and account for all company uses of SF<sub>6</sub> during the reporting year. SF<sub>6</sub> use accounted for in this approach includes: cylinders and equipment purchased during the reporting year, SF<sub>6</sub> sent off-site to destruction facilities or for recycling, SF<sub>6</sub> returned to suppliers, and SF<sub>6</sub> sold to other entities. Using this method, estimates are developed based on the assumption that any SF<sub>6</sub> gas that cannot be accounted for is emitted into the atmosphere.

SF<sub>6</sub> Partners are asked to use a standard protocol to weigh, leak check and inventory their SF<sub>6</sub> gas cylinders. This process enables companies to track gas purchases and the rate of gas use, thereby, ensuring SF<sub>6</sub> inventories are not overstocked. Since SF<sub>6</sub> cylinders are typically rented in the U.S., this approach also enables a utility to reduce their annual cylinder rental fee charge. Another important aspect of inventory tracking involves verification of the remaining gas or “heel” in returned cylinders. The term “heel” is used to describe the amount of gas that normally remains in the cylinder after use. It can account for as much

as 10 percent of the original cylinder gas mass (e.g., for a standard 52 kilograms (kg) SF<sub>6</sub> cylinder, the remaining unused gas could be roughly 5 kg). In the past, utilities typically returned cylinders to the vendor without accounting for the heel; consequently, paying for the full reported mass of the cylinder. By weighing cylinders before return, many SF<sub>6</sub> Partner utilities have been able to receive credit for the remaining portion of gas. The SF<sub>6</sub> inventory tracking system also facilitates identification of specific SF<sub>6</sub>-containing equipment requiring frequent refilling. Since increased SF<sub>6</sub> consumption (loss) may indicate mechanical or structural problems, leading to potential equipment failure, SF<sub>6</sub> Partners have used their tracking systems to schedule maintenance and equipment replacement activities before problems occur, thus saving money and reducing unplanned system disruptions.

## **2.2 SF<sub>6</sub> Recycling**

In the past during equipment servicing or replacement activities, SF<sub>6</sub> gas was typically vented to atmosphere. Now, however, most companies use SF<sub>6</sub> gas recycling carts to remove, store, clean, and re-fill the SF<sub>6</sub> gas to the gas-insulated equipment. Most recycling systems provide automatic gas purification/cleansing during removal and re-filling operations. Thus, recycling their SF<sub>6</sub> gas has enabled Partners to reduce their SF<sub>6</sub> gas purchase requirements. Additionally, many gas carts enable the equipment gas compartment to be flushed and evacuated before re-filling to ensure the removal of moisture, which reduces the likelihood of corrosion and thus increases electrical equipment lifetime.

## **2.3 Improved Leak Detection Technology**

Utilities traditionally relied on soap and water solutions or "gas sniffers" to locate SF<sub>6</sub> leaks. This process involves de-energizing the equipment, to enable the leak inspector to get close to the equipment in order to either spray liquid soap on it, or use gas "sniffer" detection devices to detect the presence of SF<sub>6</sub>. Both techniques are labor intensive, often requiring extensive climbing and reaching by workers, which is time-consuming, costly, and potentially hazardous. New laser leak detection systems exploit the strong infrared absorption characteristics of SF<sub>6</sub>. Not only do these systems enable the operator to identify leaks as small as 1 kilogram per year at distances greater than 30 meters in "real-time" (6), but they provide the ability to conduct inspection on "live" equipment. Consequently, Partners are detecting minor leaks without taking equipment out of service or incurring large downtime costs, and benefit from a significant reduction in the time required to detect leaks.

## **2.4 SF<sub>6</sub> Management Training Programs**

Critical to any successful emission reduction strategy is training to improve employee SF<sub>6</sub> handling. Effective safety and maintenance procedures, leak detection procedures, gas cart operation, gas quality testing, and arc by-product detection are all dependent on worker expertise and diligence. By implementing additional training sessions that enhance employee understanding of SF<sub>6</sub> gas issues, Partners have increased employee efficiency in monitoring SF<sub>6</sub> loss. They have also become proactive in using monitoring data to prioritize and schedule equipment maintenance and replacement.

### 3. PARTNER ACCOMPLISHMENTS

Since the SF<sub>6</sub> Emissions Reduction Partnership's inception in 1999 through 2002, cumulative reductions of nearly 132,000 kg of SF<sub>6</sub> (or over .3 million metric tonnes of carbon dioxide equivalent (MMTCO<sub>2</sub>e)) have been achieved. This translates into an overall 11 percent reduction of SF<sub>6</sub> emissions from 1999-baseline levels. Table 1 provides a summary of U.S. industry SF<sub>6</sub> emission reductions between 1999 and 2002. Additionally, during this timeframe, the average Partnership SF<sub>6</sub> emission rate (or loss rate), which is defined as the total Partnership emissions divided by the total nameplate capacity of SF<sub>6</sub>-containing equipment held by Partners, has decreased from 17 percent in 1999 to 11 percent in 2002. This accomplishment illustrates the increasing efficiency of Partner operations through the reduction in the quantity of SF<sub>6</sub> gas lost from equipment leakage or gas lost (or vented) during general cylinder handling and equipment maintenance activities.

Table 1. Summary of SF<sub>6</sub> emissions reductions achieved by Partners between 1999 and 2002.

| Reporting Year   | 1999 <sup>a</sup> | 2000  | 2001  | 2002  |
|--|-------------------|-------|-------|-------|
| SF <sub>6</sub> Nameplate Capacity (lbs. – millions)   | 3.4               | 3.8   | 3.9   | 4.0   |
| Total SF <sub>6</sub> Emissions (lbs. - thousands)     | 590               | 580   | 550   | 480   |
| Total SF <sub>6</sub> Emissions (MMTCO <sub>2</sub> e) | 15.77             | 15.18 | 14.90 | 14.08 |
| Emission Reduction from Baseline                       | —                 | 4%    | 6%    | 11%   |

<sup>a</sup>Baseline Year

With the cost of SF<sub>6</sub> ranging from US\$13 to US\$18 per kilogram, SF<sub>6</sub> emissions reductions through 2002 equate to a financial benefit ranging between US\$1.8 to US\$2.4 million dollars (approximately €1.4 to €1.9 million). The environmental benefit of this reduction is equivalent to eliminating the emissions from over 590,000 cars or planting more than 10 million trees. (7)

### **3.1 One US Utilities' Success Story**

The following information was offered by one of EPA's SF<sub>6</sub> Partners. This company has a service territory of 70,000 square miles and operates transmission equipment bearing over 200,000 pounds (nameplate capacity) of SF<sub>6</sub>. This utility's effort to reduce SF<sub>6</sub> emissions resulted in discovering that significantly more equipment was leaking than previously thought. The use of advanced leak detection technology paid for itself though the cost savings gained from reduced leaks. This company implemented policies and procedures that initially cost \$100,000 but resulted in savings in avoided gas purchases of \$400,000; yielding a net savings of \$300,000 (€237,300). The company now also recycles 90% of its SF<sub>6</sub> gas from decommissioned equipment.

Using a 1998 emissions baseline, this company reported a 50 percent reduction in annual SF<sub>6</sub> emissions in 2002. This success is based on a two-pronged approach aimed at enhancing both the company's SF<sub>6</sub> management system and facility-level maintenance procedures. The company developed a new SF<sub>6</sub> handling protocol and implemented training programs to educate employees on better leak detection practices, and SF<sub>6</sub> handling procedures, such as those required when evacuating SF<sub>6</sub> from circuit breakers, or transferring SF<sub>6</sub> from cylinders. This training has helped staff identify significant leaks on equipment, which was previously considered gas-tight.

With respect to the company's SF<sub>6</sub> management system, new measures were implemented to control purchases of SF<sub>6</sub> by improving inventory control and by reducing cylinder rental charges for late cylinder returns. The SF<sub>6</sub> tracking system has also provided a means to track equipment re-filling operations and coordinate leak detection activities more efficiently.

## **4. CONCLUSION**

SF<sub>6</sub> is the most potent greenhouse gas known. The electric power industry is the largest user and emitter of this gas. Emissions will continue to be scrutinized as greenhouse gas mitigation options are explored. While there is currently no "silver bullet" replacement for this chemical, information from the SF<sub>6</sub> Emission Reduction Partnership shows that companies can achieve significant SF<sub>6</sub> emission reductions now, using cost-effective technologies and practices that provide additional financial benefits.

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